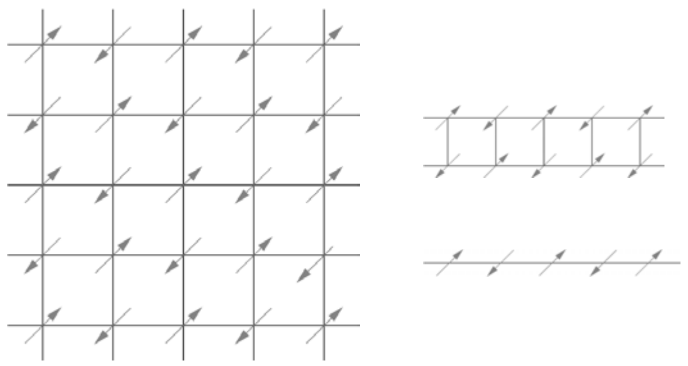
CAREER: Properties of Doped Quantum Spin Liquids

Stephan Haas, University of Southern California, DMR Award #-0089882

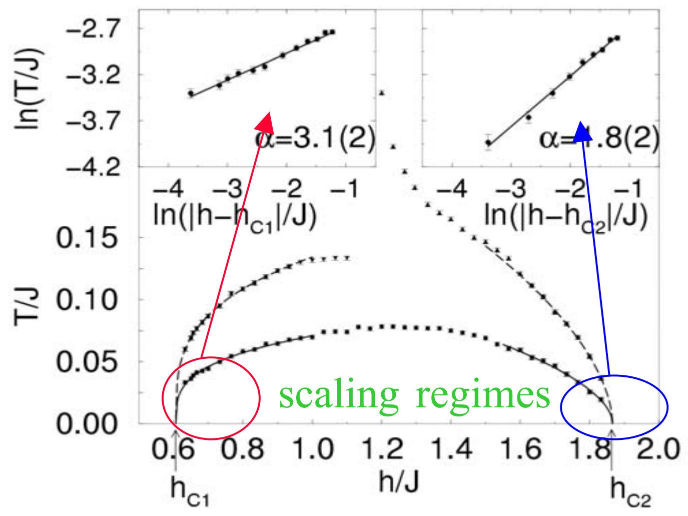


Heisenberg antiferromagnets are showcases of correlated electron systems in which quantum many body effects can be observed. They are described by the Heisenberg model of interacting spins which in the presence of a magnetic field is given by

$$H = \sum_{i,j} \left(J_{ij} \vec{S}_i \cdot \vec{S}_j \right) + h \sum_i S_i^z$$

Their properties strongly depend on geometry. For example, at zero temperature spin-1/2 Heisenberg antiferromagnets on square lattices are long-range ordered. However, chains have quasi-long-range order with spin correlations that decay algebraically with distance, and ladders are short-range ordered with exponentially decaying correlation functions.

Scaling behavior in the vicinity of quantum critical points in antiferromagnets is of great interest to the physics community. The associated power-law dependence of the critical magnetic fields on the temperature $|h - h_c| \sim T^{\alpha}$ can be determined from our Quantum Monte Carlo simulations. For weakly coupled ladders embedded in a cubic crystal we find significantly different scaling properties at the lower (h_{c1}) and the upper (h_{c2}) critical field, indicating that quantum fluctuations which are strong at the lower quantum critical point are largely suppressed at h_{c2} where the extracted exponent is close to the mean-field expectation.



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Our group currently consists of five graduate students, one postdoc, and the PI. We work on topics related to quantum magnetism, unconventional superconductivity, and nanotechnology. We investigate microscopic models of interacting electronic systems, and use numerical techniques to find their phase diagrams, ground state properties, and excitation spectra. Recently, we have applied the Stochastic Series Expansion Method to study field induced phase transitions in quantum spin liquids, developed optimization algorithms to construct nanoscale opto-electronic devices, and applied BCS theory to investigate the consequences of unconventional superconductivity in strongly correlated materials.

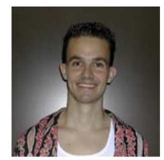
Omid Nohadani

David Parker

Rong Yu

Weifei Li

The USC Computational Condensed Matter Physics Group



Jason Thalken

Tommaso Roscilde

Stephan Haas

As part of the educational component of this CAREER award, I am organizing an annual workshop at USC for high school physics teachers which involves 20 participating teachers from Southern California. The three day program offers lectures, labs, demonstrations, and discussions on science education. The co-organizers are our director of the general education physics labs at USC and two experienced physics teachers from Los Angeles.

Further educational & outreach activities: Departmental Graduate Student Advisor, Los Angeles Physics Teachers Association, California Science Fair.